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RESEARCH MEMORANDUM

RESULTS OBTAINED FROM SECOND FLIGHT OF X-4 AIRPLANE (A.F. No. 46-676)

By Walter C. Williams

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SUMMARY

NACA instrumentation has been installed in the X-4 airplanes to obtain stability and control data during the Northrop conducted acceptance tests. The results of the second flight of the X-4 number 1 airplane are presented in this report. This flight was made with the center of gravity at 19.7 percent of the mean aerodynamic chord and with the rudder-boost system removed.

The results of the flight showed that the longitudinal stability was positive in the clean condition and in the gear-down flaps-up condition. Records taken during landing approach and in a steady run at 170 miles per hour showed that the lateral oscillation is poorly damped. The pilot reported that the rudder control was adequate.

INTRODUCTION

As a part of the Air-Force - Navy - NACA transonic flight research program, the Northrop Company has constructed the X-4 airplane. This airplane is intended for performing research on a tailless configuration at high subsonic Mach numbers.

NACA recording instrumentation has been installed in the airplane to provide data on stability and control characteristics during the Northrop conducted acceptance tests. The present report gives data obtained in the second flight with this airplane, made April 27, 1949. For this flight, the center of gravity was located at 19.7 percent mean aerodynamic chord in comparison with the location of 22 percent mean aerodynamic chord for the first flight reported in reference 1. In addition, the rudder boost was removed and a direct control linkage was installed.

SYMBOLS

V_i	indicated airspeed, miles per hour
β	sideslip angle, degrees
δ_e	elevon angle, degrees
δ_r	rudder angle, degrees
q	dynamic pressure, pounds per square foot
S	wing area, square feet
W	airplane weight, pounds
C_n	airplane normal-force coefficient $\left(\frac{nW}{qS}\right)$
n	normal acceleration

Subscripts:

R, L	right and left elevons, respectively

AIRPLANE

The Northrop X-4 airplane is a semitailless research airplane having a vertical tail but no horizontal tail surfaces. It is powered by two Westinghouse J30-WE-7-9 engines and is designed for flight research in the high-subsonic speed range. Photographs of the airplane are presented in figure 1 and a three-view drawing of the airplane is presented in figure 2. Table I lists the physical characteristics of the airplane.

TEST INSTRUMENTATION

Because of the small size of the X-4 airplane and the instrumentation requirements for the Northrop structure and engine temperature measurements, it was possible to install only a minimum of stability and control instrumentation. Standard NACA internal instruments record altitude, airspeed, angle of sideslip, right and left elevon position, and rudder position. In addition, the following quantities are telemetered to a ground station: normal acceleration, altitude, airspeed, right and left elevon position, and rudder position. All the records are correlated by a common timer.

The recording airspeed and altimeter are connected to the airspeed head on the vertical fin. A calibration of this installation has not yet been made.

RESULTS AND DISCUSSION

During this flight, the pilot took records of stabilized runs at three speeds, 170, 210, and 290 miles per hour indicated airspeed at altitudes from 12,000 to 15,000 feet and also a record of the landing approach and landing. The speeds presented with the data herein are only approximate since there was a leak on the static-pressure side of the recording airspeed system in a line in the instrument compartment.

The trim data from the three speed runs are presented in figure 3 where the longitudinal control is represented by the average elevon deflection, and the lateral control is presented as the difference between the right and left elevon deflection. The variation of the longitudinal-control angle with speed as given in figure 3 shows that the airplane possesses adequate position stick-fixed longitudinal stability with the center of gravity at 19.7 percent mean aerodynamic chord as compared with the slight instability with the center of gravity at 22 percent mean aerodynamic chord shown in reference 1.

A time history of the landing approach and landing is given in figure 4. From this figure it can be seen that the airplane possessed slight positive longitudinal stability with the landing gear down and flaps up as evidenced by the increase in upward elevon deflections as the speed was decreased. Approximately 14° of longitudinal control was used for landing which left adequate control for lateral motions of the airplane. It should be pointed out, however, that this landing was made well above minimum speed without flaps. It should be noted that during the approach to landing, the small movements of the rudder caused a lateral oscillation that was slow to damp and even continued at small amplitudes with the rudder held fixed. Figure 5 gives a further example of the poor damping of the lateral oscillation. This figure is a time history of the stabilized run which the pilot made at 170 miles per hour indicated airspeed. It should be noted that the controls are held essentially fixed while the airplane oscillated in sideslip. Figure 4 and figure 5 indicate that the lateral oscillation has a period of approximately 2 to 3 seconds and that the oscillation damps to half-amplitude in approximately 4 to 5 seconds.

The pilot was satisfied with the longitudinal stability with the center of gravity at 19.7 percent mean aerodynamic chord. The rudder control was considered adequate. Although the pilot did not consider the poor damping of the lateral oscillation objectionable at the speeds for which data are presented herein, he encountered a poorly damped lateral oscillation at 290 miles per hour which he considered very objectionable. The pilot, however, did not get a record of this oscillation.

CONCLUSIONS

From data obtained from the second flight of the X-4 number 1 airplane, it is indicated that:

1. The airplane has positive longitudinal stability with the center of gravity at 19.7 percent mean aerodynamic chord in the clean condition and in the gear-down flaps-up condition.

2. The lateral oscillation appears to be poorly damped.

3. The rudder control was reported by the pilot to be adequate.

Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Air Force Base, Va.

REFERENCE

1. Drake, Hubert M.: Stability and Control Data Obtained from First Flight of X-4 Airplane. NACA RM L9A31, 1949.

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TABLE I

PHYSICAL CHARACTERISTICS OF X-4 AIRPLANE

Engines (two)	Westinghouse J-30-WE-7-9
Rating (each), static thrust at sea level, pounds	1600
Weight for acceptance tests, pounds:	
Maximum (240 gal fuel)	7050
Minimum (10 gal fuel trapped)	5670
Wing loading, pounds per square foot:	
Maximum	35.2
Minimum	28.3
Center-of-gravity travel (first flight), percent MAC:	
Gear down, full load	22.5
Gear down, empty	20.2
Gear up, full load	22.0
Gear up, empty	19.7
Height, over all, feet	14.83
Length, over all, feet	23.25
Wing:	
Area, square feet	200
Span, feet	26.83
Airfoil section	0010.64
Mean aerodynamic chord, feet	7.81
Aspect ratio	3.6
Root chord, feet	10.25
Tip chord, feet	4.67
Taper ratio	2.2:1
Sweepback (leading edge), degrees	41.57
Dihedral (chord plane), degrees	0
Wing flaps (split):	
Area, square feet	16.7
Span, feet	8.92
Chord, percent wing chord	25
Travel, degrees	30
Dive brake dimensions as flaps:	
Travel, degrees	±60
Elevons:	
Area (total), square feet	17.20
Span (2 elevons), feet	15.45
Chord, percent wing chord	20
Movement, degrees:	
Up	35
Down	25
Operation	Hydraulic with electrical emergency
Vertical tail:	
Area, square feet	16
Height, feet	5.96
Rudder:	
Area, square feet	4.1
Span, feet	4.3
Travel, degrees	30

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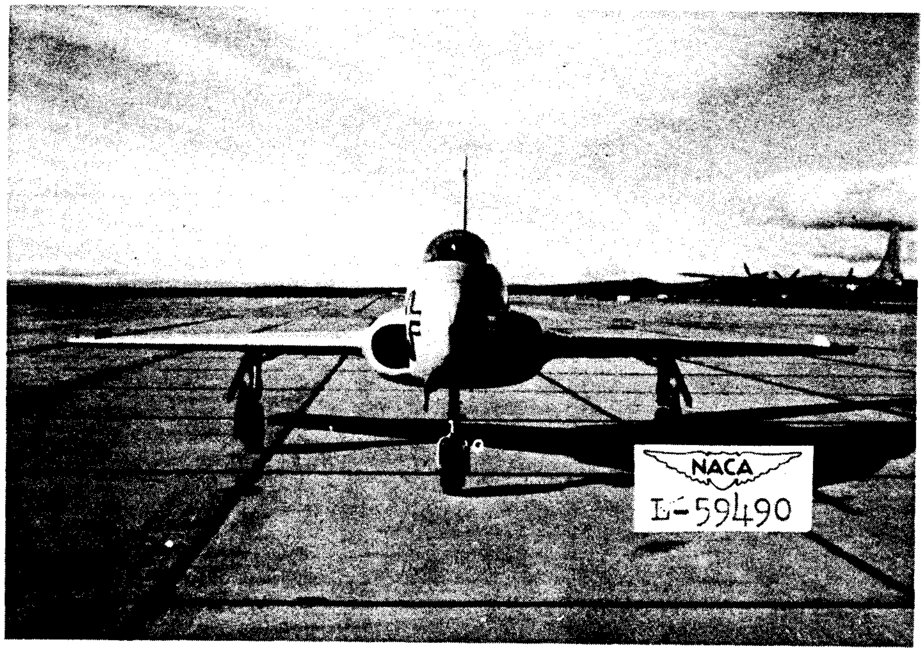

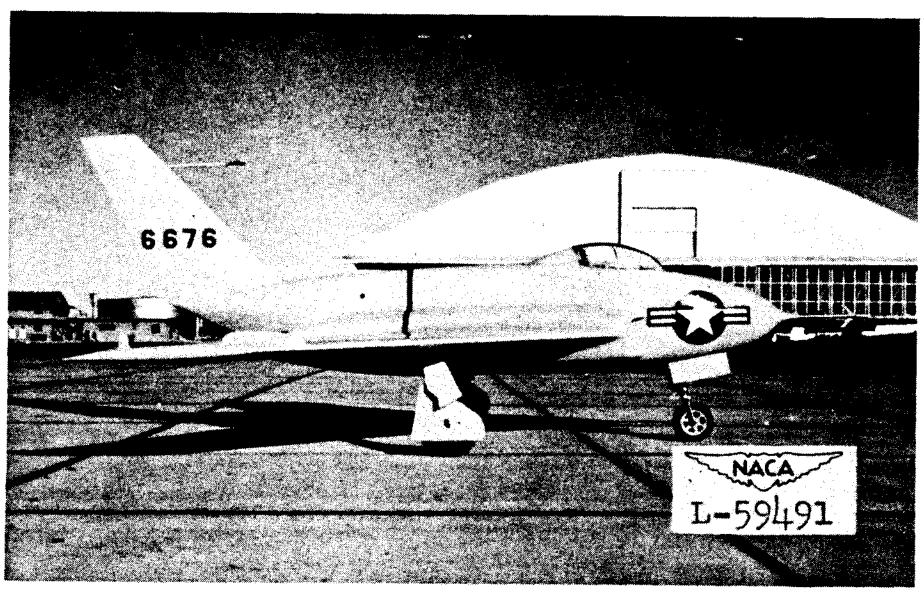

Figure 1.- Photographs of X-4 airplane.

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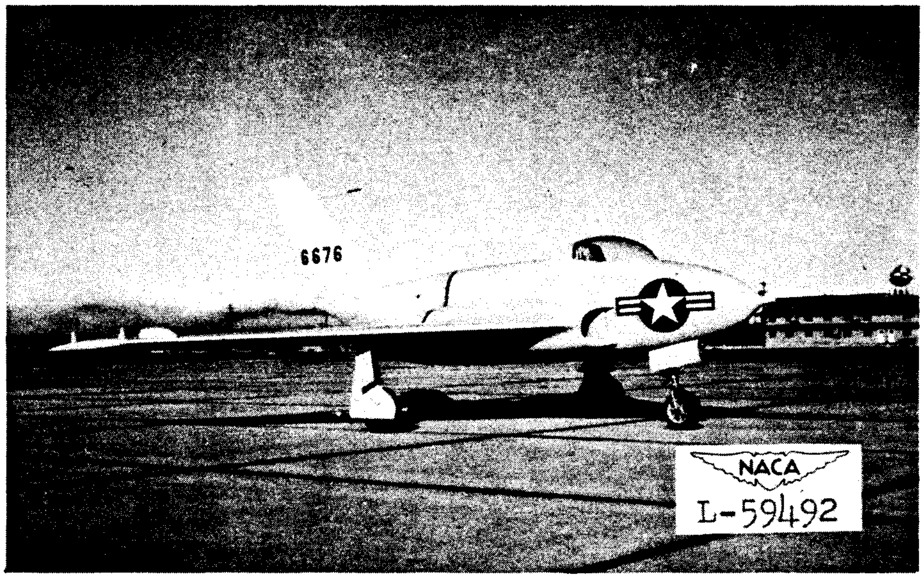

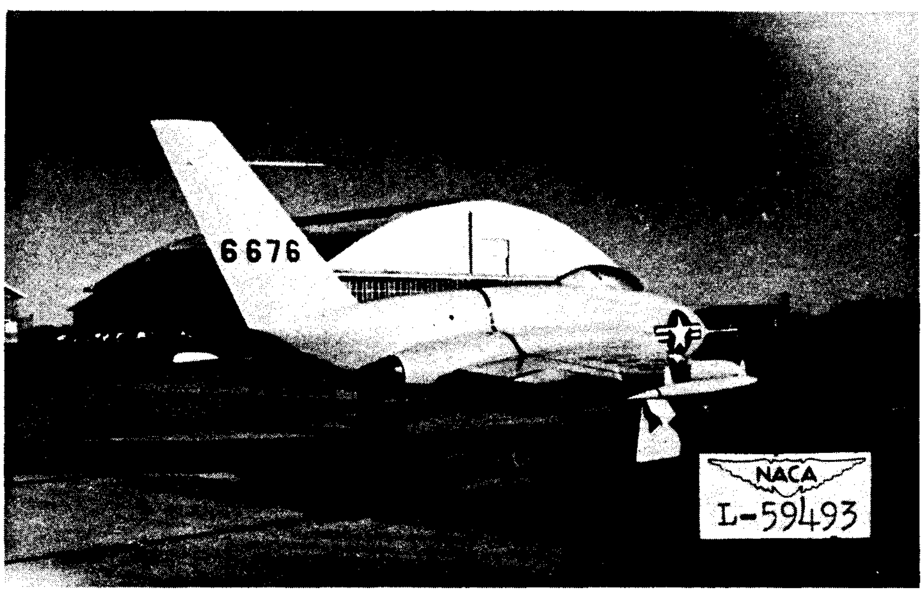

Figure 1.– Concluded.

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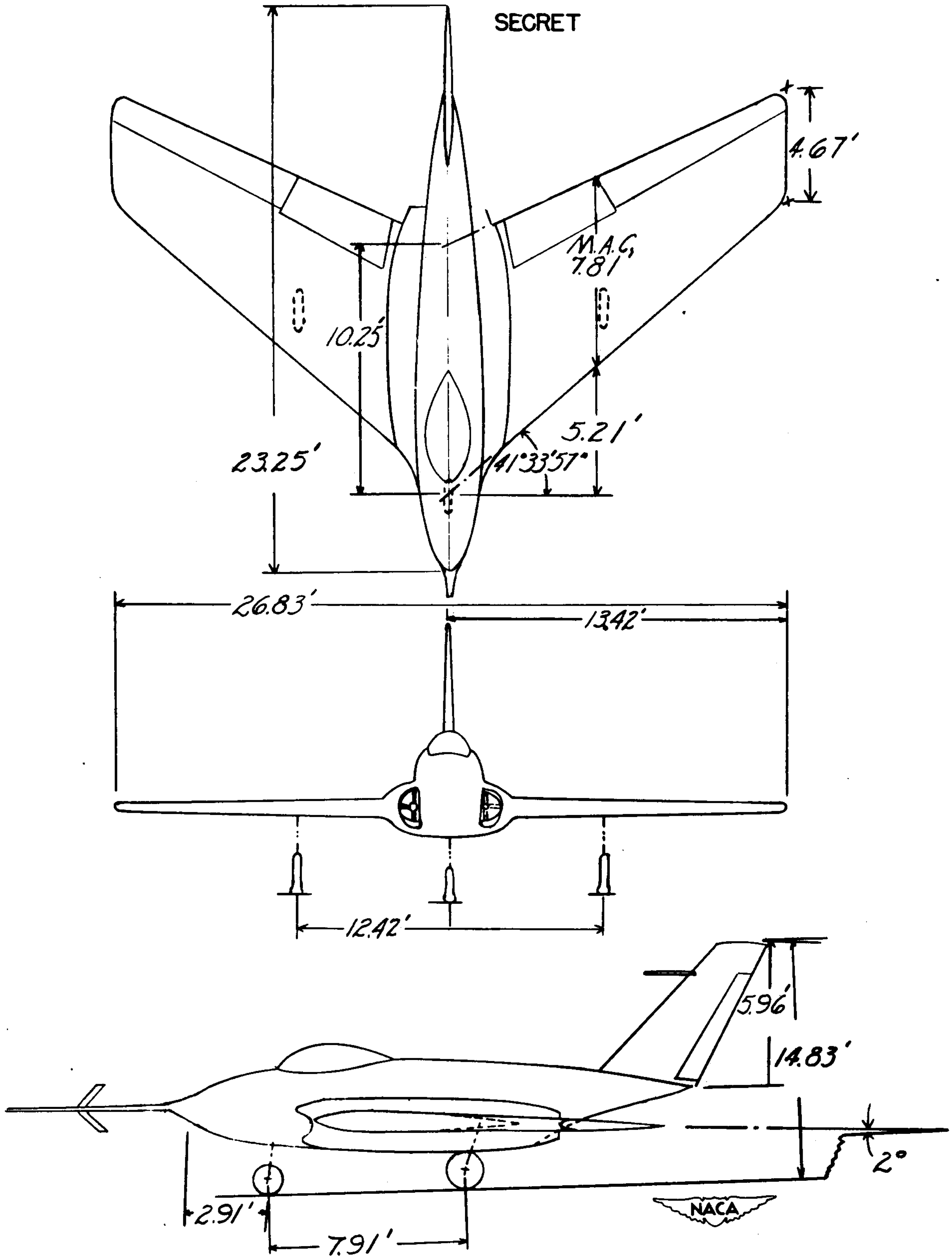

Figure 2.– Three-view drawing of X-4 airplane.

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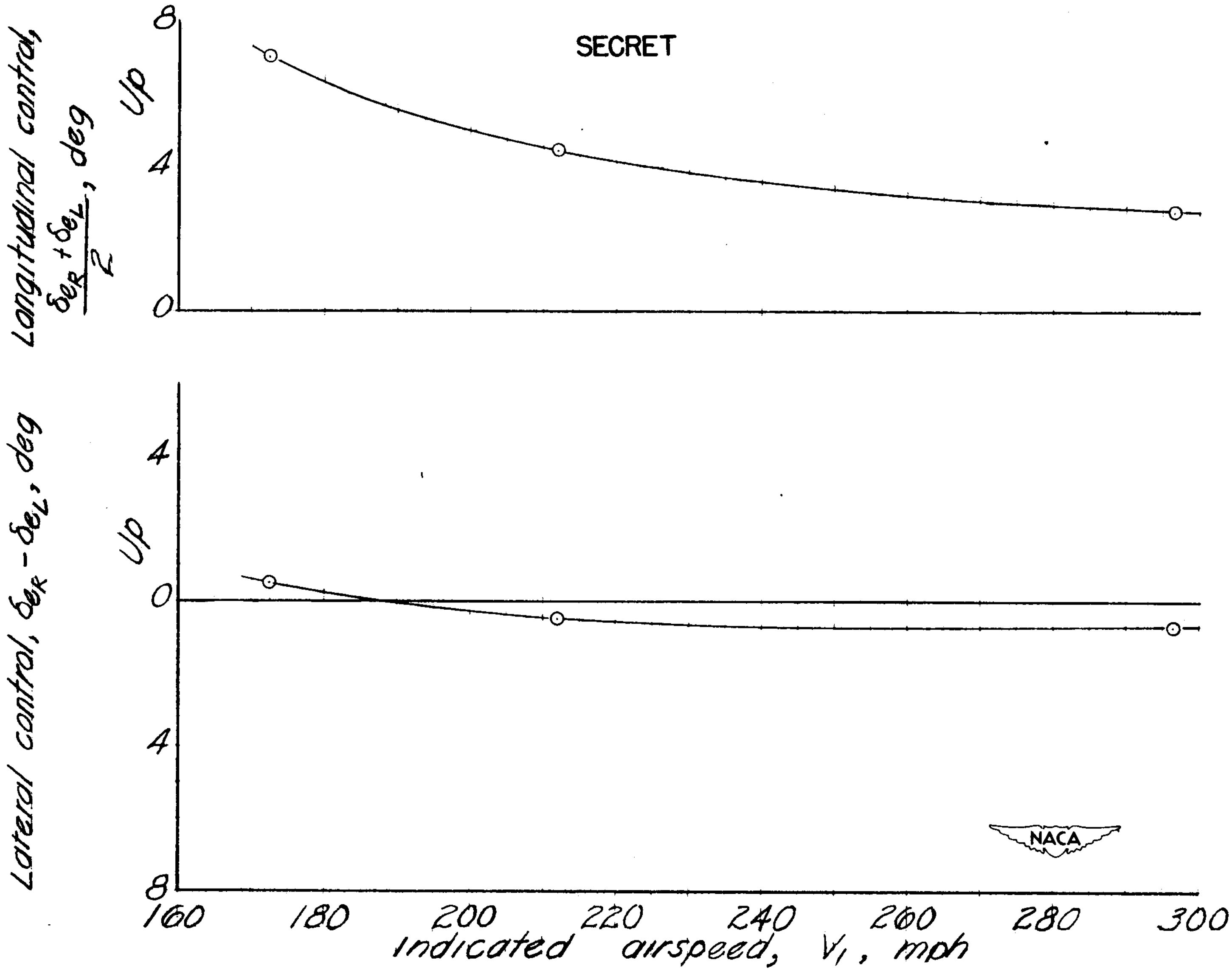

Figure 3.- Variation of longitudinal and lateral control deflection with indicated airspeed. X-4 airplane.

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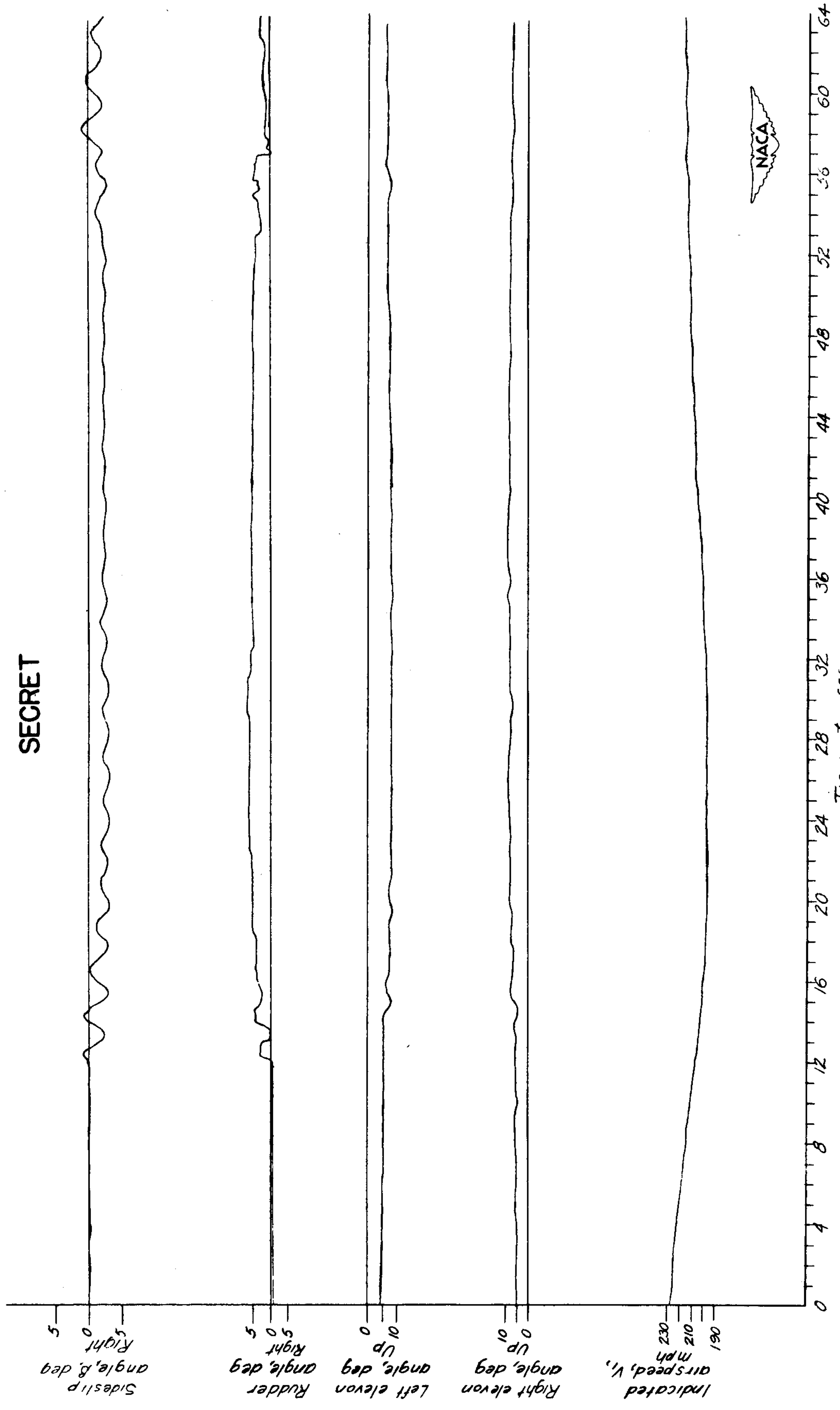

Figure 4.- Time history of landing approach and landing. X-4 airplane.

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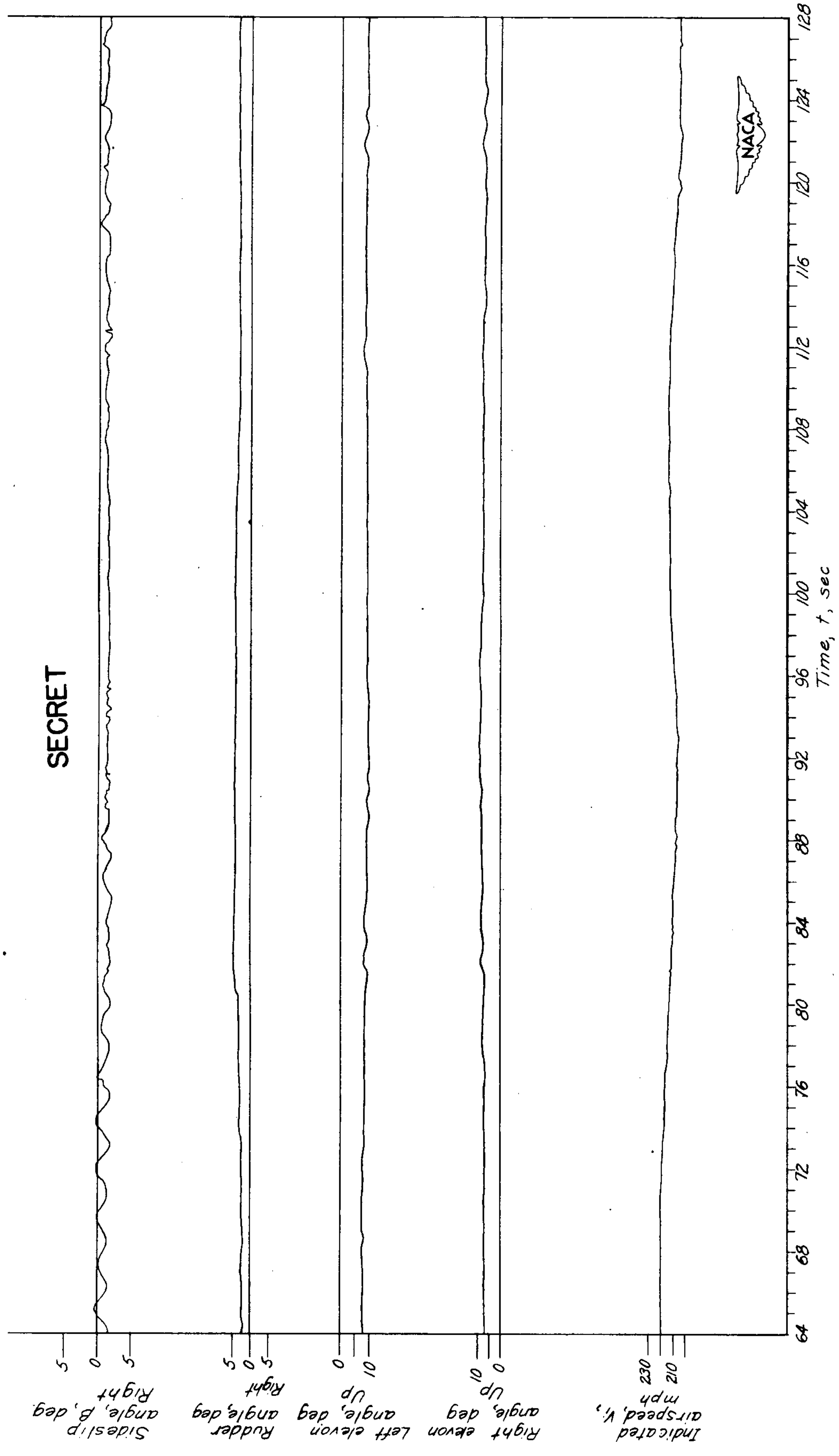

Figure 4.- Continued.

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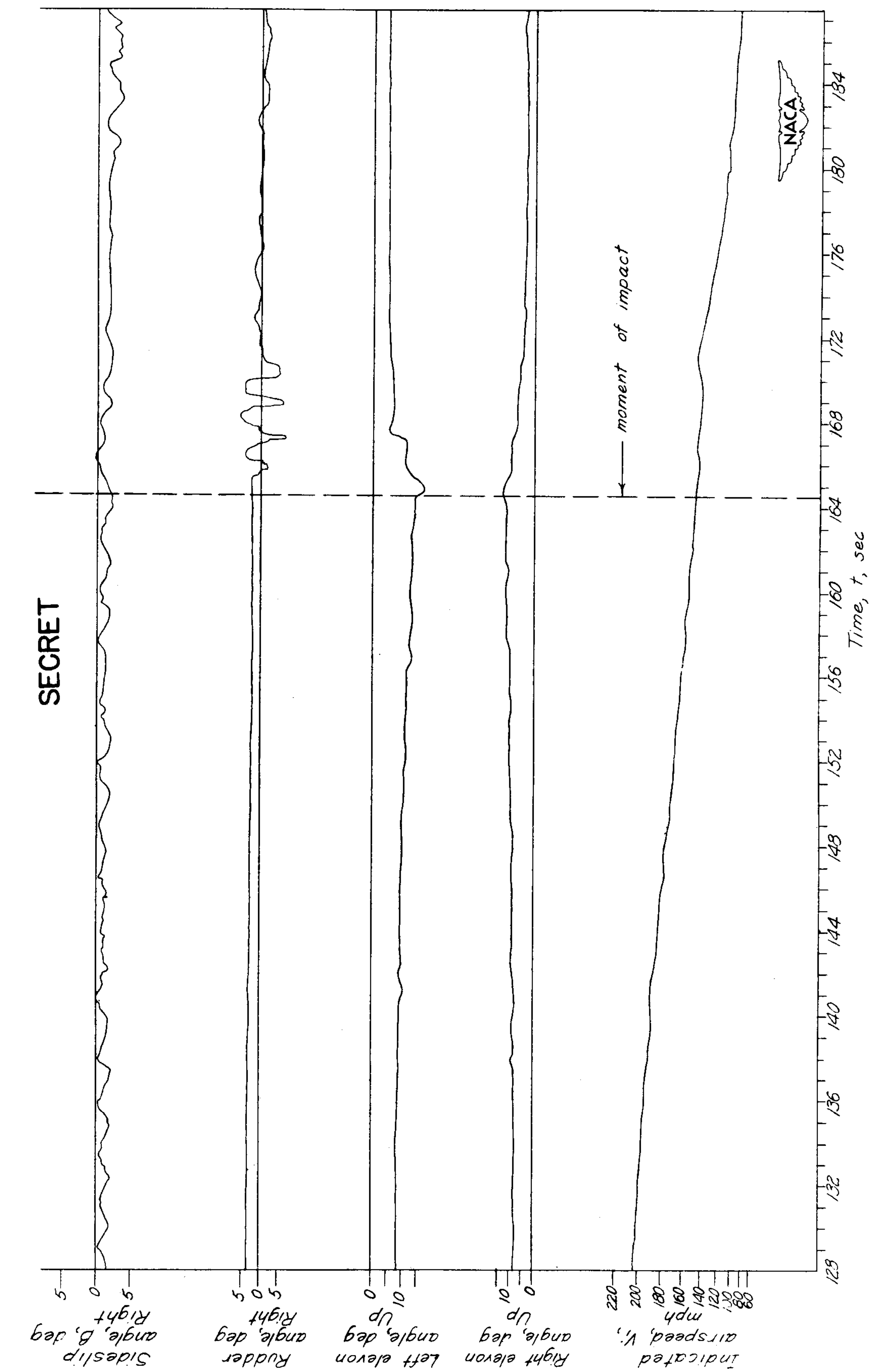

Figure 4.- Concluded.

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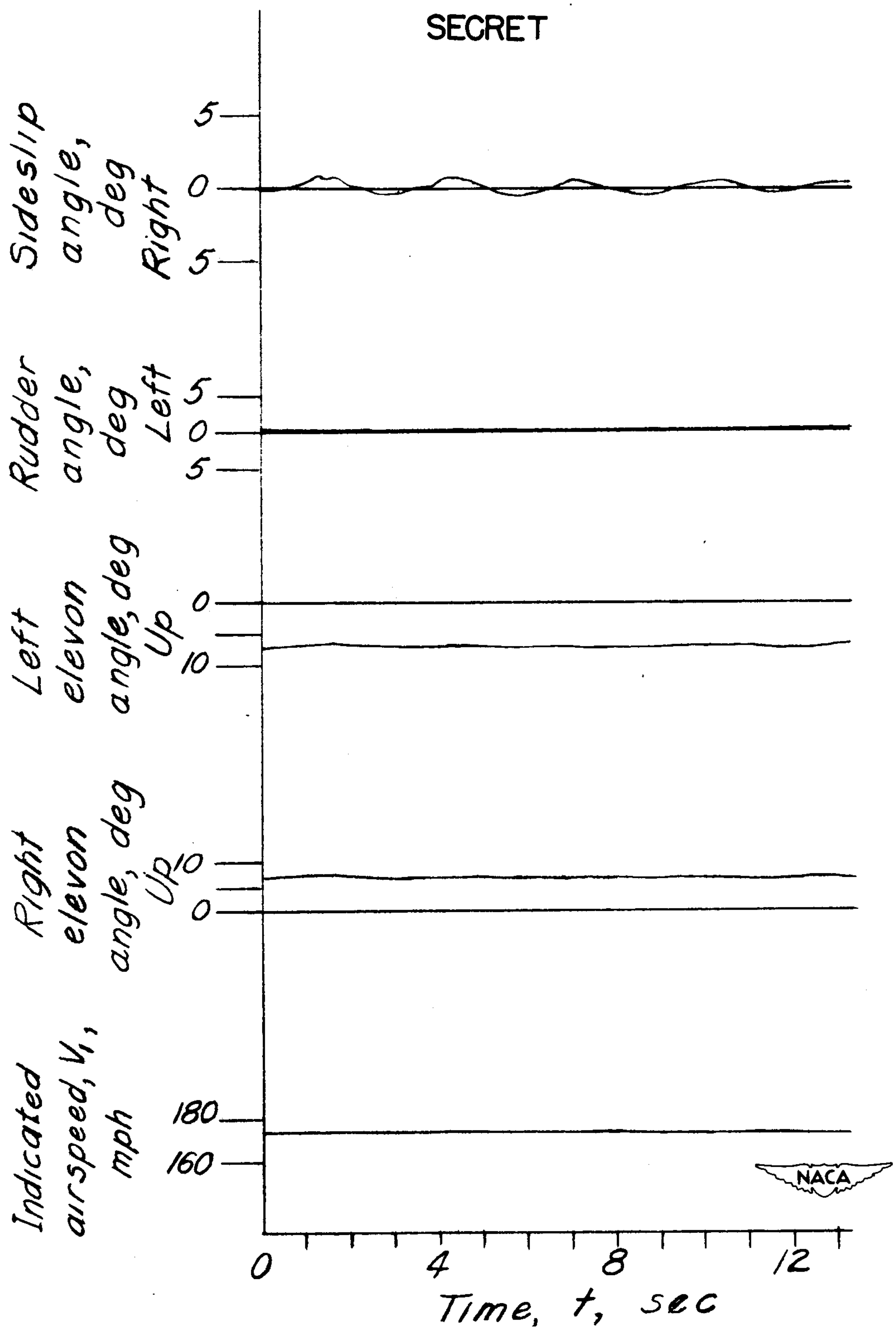

Figure 5.- Time history of lateral oscillation during stabilized run. X-4 airplane.

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